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MICROSCULPTURE OF CUCKOO WASPS (HYMENOPTERA, CHRYSIDIDAE): GENERAL OVERVIEW WITH FIRST ATTEMPT OF CLASSIFICATION

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The variety of surface sculpture in European cuckoo wasps was estimated. Preliminary 14 main forms of miscrosculpture within 5 major types were distinguished, and some combined and complex forms were additionally described. Punctures were shown to be structurally highly various. The variability of punctuation and its taxonomical significance were highlighted.

Key words: cuckoo wasps, microcsulpture, punctuation.

Микроскульптура ос-блестянок (Hymenoptera, Chrysididae): общий обзор и первая попытка классификации. Мартынова Е.В.
В работе оценено разнообразие скульптурных образований на покровах европейских ос-блестянок. Предварительно было выделено 14 основных форм микроскульптуры в пределах 5 ее типов, также дополнительно описаны комбинированные и сложные формы микроскульптуры. Было показано, что точки структурно разнообразны. Вариабельность пунктировки и ее таксономическое значение также обсуждены.

Ключевые слова: осы-блестянки, микроскульптура, пунктировка.

Мікроскульптура ос-блискіток (Hymenoptera, Chrysididae): загальний огляд та перша спроба класифікації. Мартинова К.В.
В роботі оцінено різноманіття скульптурних формувань на покривах європейських ос-блискіток. Попередньо було виділено 14 основних форм мікроскульптури в межах 5 її типів, також додатково описано комбіновані та складні форми мікроскульптури. Було показано, що пункти структурно різноманітні. Варіабельність пунктирування та його таксономічне значення також обговорено.

Ключові слова: оси-блискітки, мікроскульптура, пунктирування.

Introduction. The chrysidid wasps (Hymenoptera, Chrysididae), also called cuckoo wasps are a family of world-wide distributed parasitic hymenopterans. They are most commonly recognized by reduced number of metasomal segments and bright structural (metallic) coloration in most of species. The cuticle of cuckoo wasps is rather tough and hard. It protects the adults when they are attacked by the hosts.

Various teeth, grooves, pit rows, carinae and foveae constitute the macrosculpture of cuticle in chrysidid wasps. These are widely used in taxonomy and therefore were accurately described and

named (Berland, Bernard, 1938; Balthasar, 1954; Linsenmaier, 1959, 1968; Kimsey, Bohart, 1991).

The microsculpture refers to minute patterns of the surface of the cuticle and is frequently used to distinguish species of cuckoo wasps. Authors had proposed a number of names and terms to differ the forms of surface sculpturing, but these had never been unified or correlated. Many chrysidid species were originally described with notes on microsculpture, but only a few were provided with illustrations.

The main forms of microsculpture had been previously illustrated and named for the order Hymenoptera (Eady, 1968; Harris, 1979). The used names were discussed and the importance of the consistent and correct use of descriptive terms for efficient taxonomic work were highlighted (Harris, 1979).

The present contribution is aimed to evaluate the variety of surface sculpturing in cuckoo wasps and to propose the unified terminology, which can be applied to the microsculpture.

Materials and methods. The species of chrysidid wasps in all genera of European fauna were studied. More than 100 species were minutely studied under the light binocular microscope MBS-10 and Olympus SZX 10 research high-class stereo microscope. The Detla Optical LED 64 was used as basic illumination. All drawings provided were made using this circular LED. The scanning electron microscopy was also used to ascertain the pattern of surface sculpturing in two species of cuckoo wasps; the research was conducted at JEOL JSM 7401F (4kV) scanning microscope on the base of Laboratory of electron microscopy of the Institute of Parasitology (Biology Centre) of the Czech Academy of Sciences. The drawings and photographs were processed with Adobe Photoshop software.

Results

Types and forms of microsculpture. All the variety of surface sculpturing in cuckoo wasps can be divided into 14 main forms within 5 major types:

Type 1: Striate microsculpture, *Form 1:* Aciculate
Form 2: Strigate
Form 3: Canaliculate
Type 2: Rugose microsculpture, *Form 4:* Rugulose
Form 5: Rugose
Form 6: Folded
Type 3: Pustulate microsculpture, *Form 7:* Pustulate, with setae
Type 4: Coriaceous microsculpture, *Form 8:* Alutaceous
Form 9: Coriaceous
Type 5: Punctuation, *Form 10:* Punctulate
Form 11: Double-punctate
Form 12: Triple-punctate
Form 13: Rugose-punctate
Form 14: Reticulate

The body surface in cuckoo wasps is majorly covered with punctuation (Fig. 1). It can be treated as 'dense' or 'loose' regarding the location pattern of punctures, and 'fine' or 'coarse' regarding the depth of punctures.

The head and metasomal tergites are generally covered with punctulate microsculpture. The mesosoma is the most variously sculptured part of chrysidid body. Its dorsal surface is usually heterogeneously punctured, and the lateral parts may bear some forms of striate and rugose microsculpture.

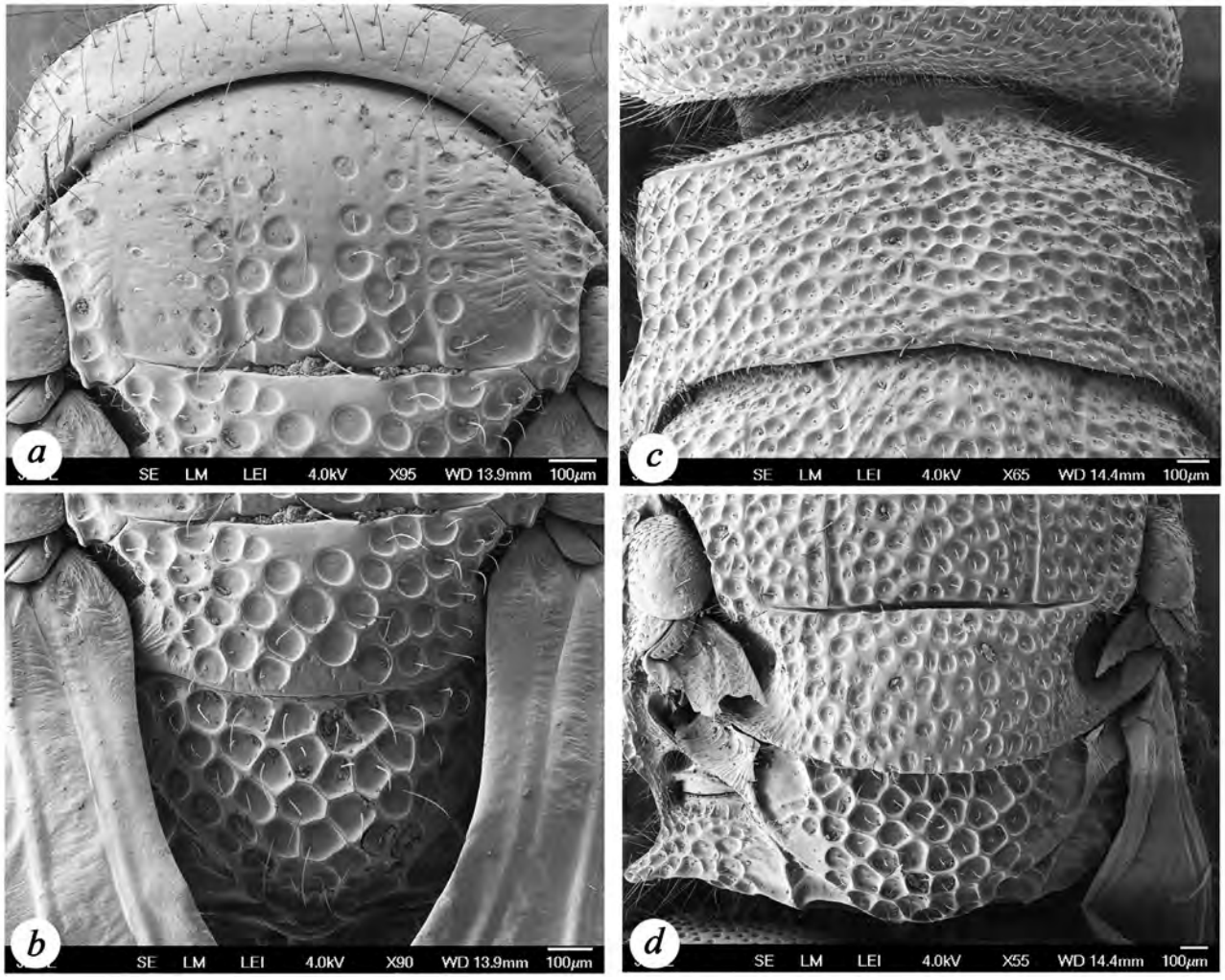

Fig. 1. Surface sculpture of cuckoo wasps: *a* and *b* – *Pseudomalus auratus* (Linnaeus, 1758), pronotum, scutum and metanotum; *c* and *d* – *Hedychridium valesiense* Linsenmaier, 1959, pronotum, scutum and metanotum.

The striate, rugose, pustulate and coriaceous microsculpture are much less frequently found at body surface, than the punctuation. Usually only the separate zones of certain sclerites bear these types of surface sculpture. Accept of being punctured, the scapal basin and the lateral pronotal depression may be striate or rugose, the metasomal sternites may be pustulate, the sclerites of mesosoma and laterotergites of metasoma may be coriaceous, etc.

The listed forms of microsculpture may solely occur at certain sclerites, but occasionally one form may turn to another one or they can combine forming the complex forms of microsculpture. All the main forms of surface sculpture in cuckoo wasps, and those defined as complex or combined, are illustrated in the tables 1 and 2: the names of forms is given in English, Ukrainian and Russian, the characteristics of surface sculpture are provided to define each form; the configuration of cuticle surface in cross section is illustrated.

The surface configuration. The line drawings of cuticle surface configuration in cross section appear to be useful while differentiating the forms of microsculpture in cuckoo wasps. These can clearly indicate the presence and size of depressions, folds and swellings at the cuticle surface. They may also reveal the minute differences in microsculpture attributed to one type, e.g. in the depth and edge configuration of punctures, location of setae, height of the interstices between punctures (Fig. 2).

The drawings showing the surface configuration of the cuticle are actually the complex schemes, which should be compiled after the minute examination of body surface under the different angles of view.

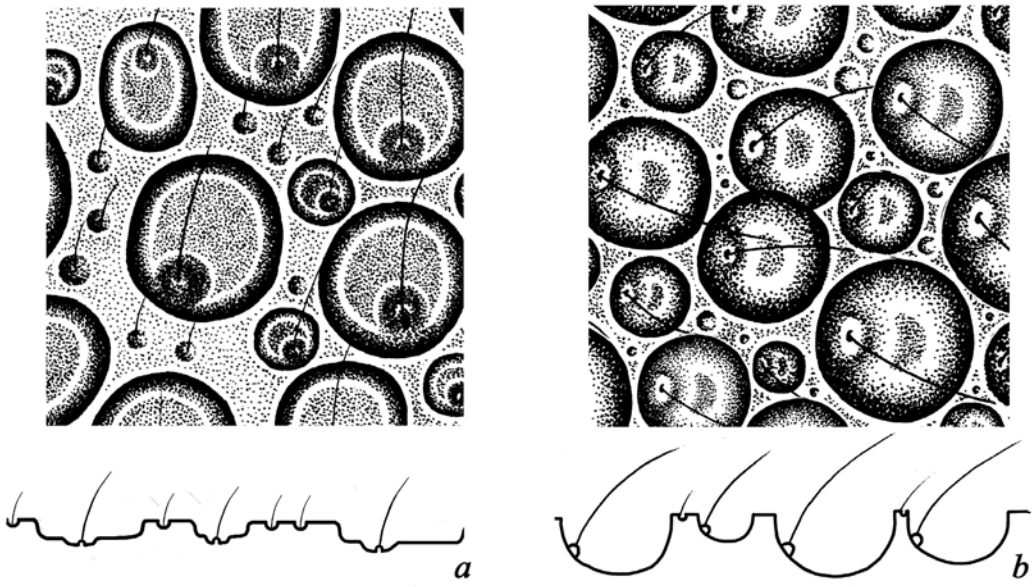

Fig. 2. Triple-punctate microsculpture at metanotum of *Chrysis zetterstedti* Dahlbom, 1790 (a) and at pronotum of *C. cylindrica* Eversmann, 1857 (b): top views on the cuticle and the line drawings of cuticle configuration in the cross section.

The punctures at chrysidid cuticle are the characteristic deepenings bearing the setae (Fig. 3, a–c); even the smallest punctures bear the setae, which may be very short (Fig. 3, d–e). The setae viewed from above seem to be thin and needle-like, but they may turn to be actually laterally flattened and lamellate (Fig. 3, c). The additional research is needed to ascertain the minute structure and variety of setae of Chrysididae.

The punctures found at cuticle of cuckoo wasps are highly various (Fig. 4). They differ in size, shape, depth, edge configuration, bottom configuration, location of seta. Despite the general variety, the punctures of separate sclerites usually appear to be homogenous.

The cuckoo wasps of higher taxa reveal some similarities in the structure of punctures, especially that of the pronotum and scutum. The chrysidid wasps of the genus *Cleptes* Latreille, 1802 (subfamily Cleptinae) bear slope-edged acclivous punctures at pronotum, scutum and scutellum. Cuckoo wasps in the subfamily Chrysidinae generally have sharp-edged punctures: within the tribe Elampini these punctures are flat-bottomed with setae inserted in the center; within the tribes Chrysidini and Parnopini the punctures may be of various shapes, but are generally round-bottomed with setae inserted at the 'side walls' (between the bottom and edge of puncture).

Some genera also reveal special characters in the sculpture of the pronotum and scutum: species of the genus *Chrysellampus* Semenov, 1932 have interstices covered with coriaceous microsculpture; representatives of the genera *Hedychridium* Abeille de Perrin, 1878 and *Hedychrum* Latreille, 1802 bear characteristic navel-shaped punctures (setae inserted in the middle are surrounded by the circular platens); species of *Spinolia* Dahlbom, 1854 and *Pseudospinolia* Linsenmaier, 1951 have pronotum and scutum triple-punctate, etc.

Variability of microsculpture. In cuckoo wasps the general pattern of microsculpture, and especially the structure of punctures, is the stable character. Thus, the characteristics of microsculpture

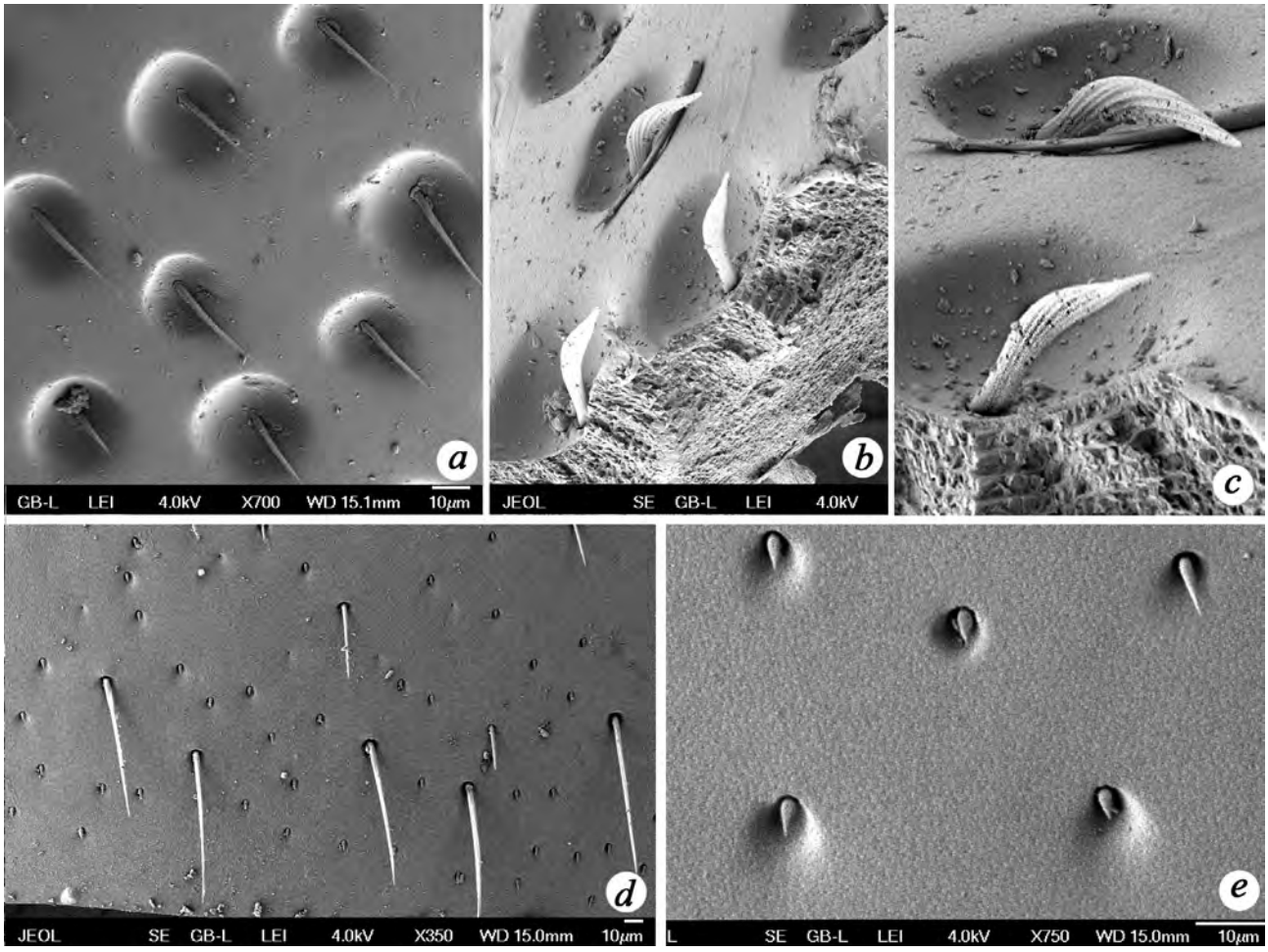

Fig. 3. Punctures at cuticle of cuckoo wasps: a – *Hedychridium valesiense* Linsenmaier, 1959, top view of the second metasomal tergite, b and c – the same, anterolateral view (note the structure of setae), d and e – *Pseudomalus auratus* (Linnaeus, 1758), top view of the second metasomal tergite.

at various body parts are widely used to distinguish species, species groups and genera of Chrysididae (Linsenmaier, 1959, 1968, 1987; Kimsey, Bohart, 1991; Smissen, 2010). Some species are easily differed among other related ones by the features of surface sculpturing, e.g. *Chrysis subcoriacea* Linsenmaier, 1959 by the punctuation of the second metasomal tergite, *Holopyga fervida* (Fabricius, 1781) by the location pattern of punctures at scutellum, etc.

From the other hand, in chrysidids, as in many other parasitoid hymenopterans, the specimens of one species considerably vary in size. The 'biggest' specimens of the species can be almost twice longer than the 'smallest' ones: e.g. the body length in *Stilbum cyanurum* (Forster, 1771) varies from 5 to 19 mm, in *Hedychrum niemelai* Linsenmaier, 1959 from 4 to 8 mm, in *Chrysis leachii* Shuckard, 1837 from 3 to 6 mm (Linsenmaier, 1959).

The specimens of one species which considerably differ in size, also differ in the characteristics of microsculpture, especially in that of punctuation. The smaller specimen bears the smaller punctures, but the diameter of its punctures always appears to be disproportionally bigger in relation to the length and width of the sclerites, body parts or whole body (Fig. 5). Thus, the punctures of 'smaller' specimen are always bigger than might be expected in proportional decrease in relation to the 'bigger' specimens (in addition to the fact that the small specimen is not a small copy of the bigger one). Moreover, the punctures of the 'smaller' specimens are generally more closely located than that of the 'bigger'

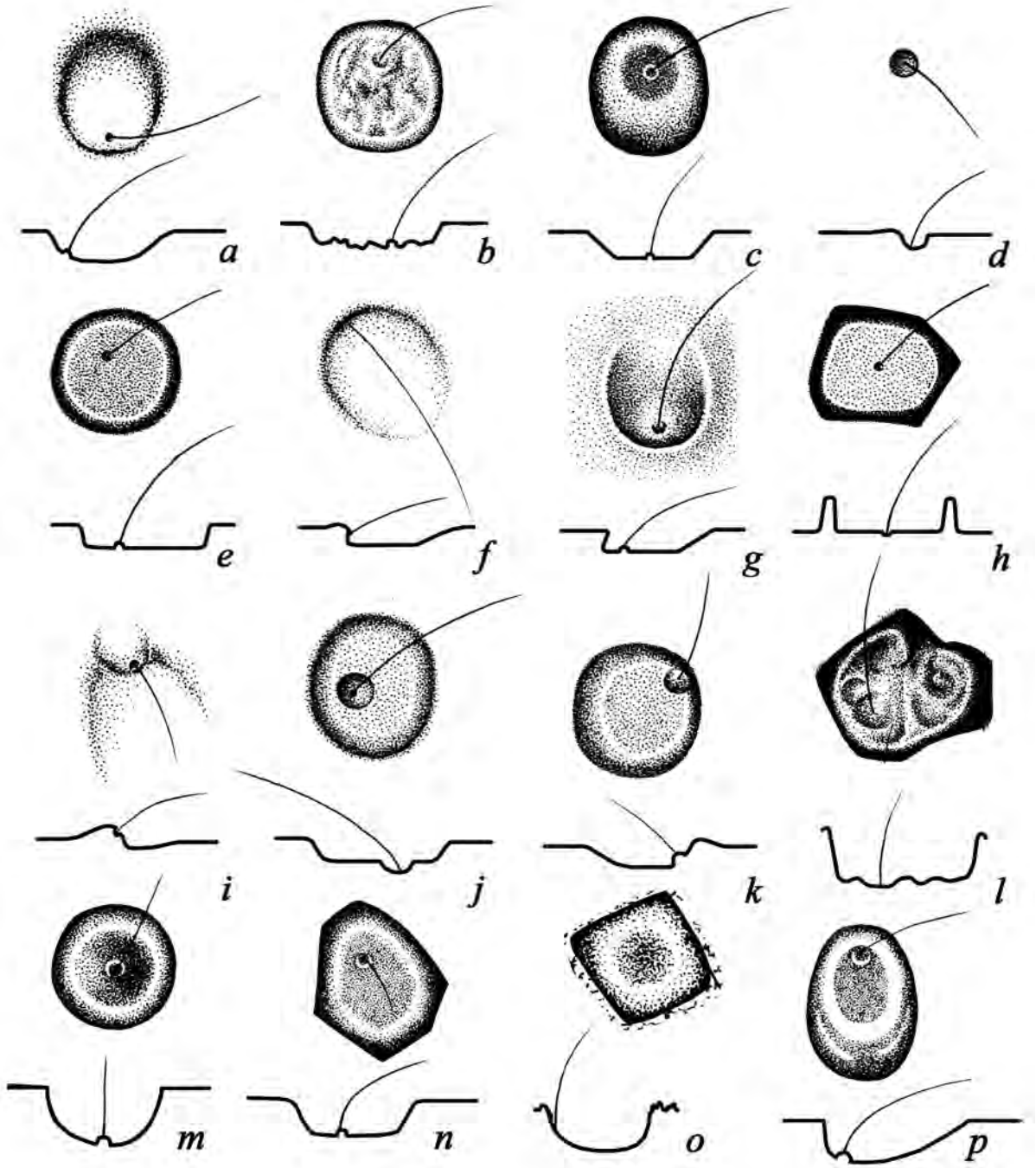

Fig. 4. Variety of punctures found at cuticle of cuckoo wasps: *a* – *Chrysidea pumila* (Klug, 1845), scutellum, *b* – *Pseudomalus violaceus* (Scopoli, 1763), pronotum, *c* – *Chrysis chrysoprasina* Förster, 1853, scutellum, *d* – *Philoctetes bidentulus* (Lepeletier, 1806), metasomal tergite II, *e* – *Chrysellamus sculpticollis* (Abeille, 1878), scutum, *f* – *Chrysura dichroa* (Dahlbom, 1845), metasomal tergite II, *g* – *Chrysis chrysoprasina*, scapal basin, *h* – *Holopyga fasuosa generosa* (Förster, 1853), metanotum, *i* – *Chrysis fulgida* Linnaeus, 1761, metasomal tergite II, *j* – *H. fervida* (Fabricius, 1781), scutum, *k* – *Chrysis sexdentata* Christ, 1791, scutellum, *l* – *Hedychridium iucumdum* Mocsáry, 1889, metanotum, *m* – *Hedychrum virens* Dahlbom, 1954, scutellum, *n* – *Omalus aeneus* (Fabricius, 1787), scutellum, *o* – *Chrysidea pumila*, metasomal tergite II, *p* – *Chrysis longula* Abeille, 1879, scutellum.

specimens, their interstices are shortened; the number of punctures per sclerite are always smaller in 'smaller' specimens. This results in generally more large and dense punctuation, and therefore more matt color, of the 'smaller' specimens if compared to the 'bigger' more shining specimens of the species.

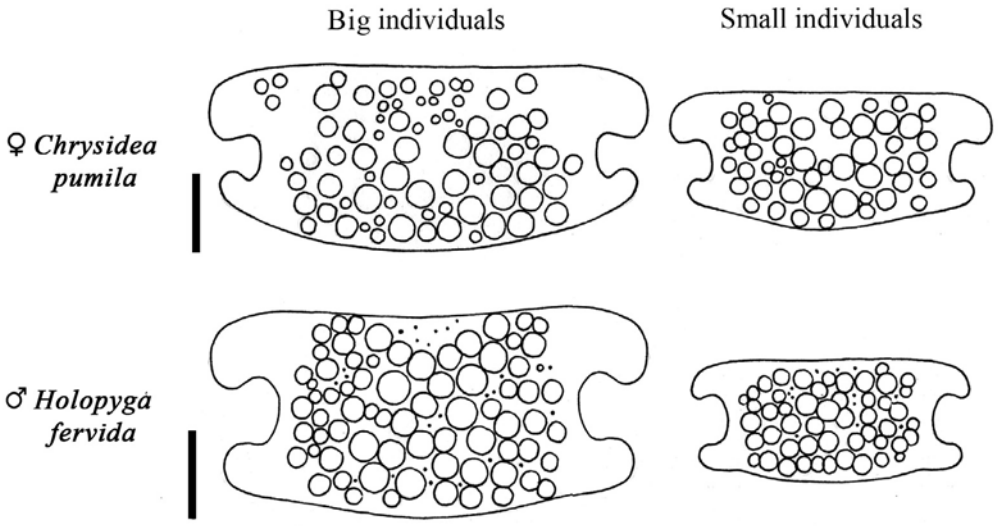

Fig. 5. Scheme showing the difference in the scutellar punctuation of the big and small specimens of *Chrysidea pumila* (Klug, 1845) and *Holopyga fervida* (Fabricius, 1781). Scale bar 1 mm.

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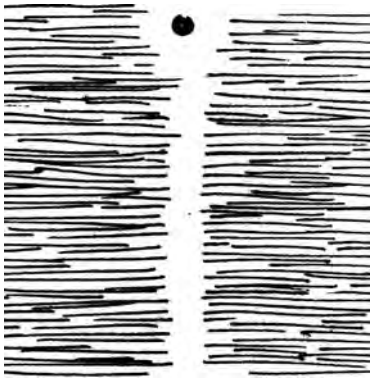
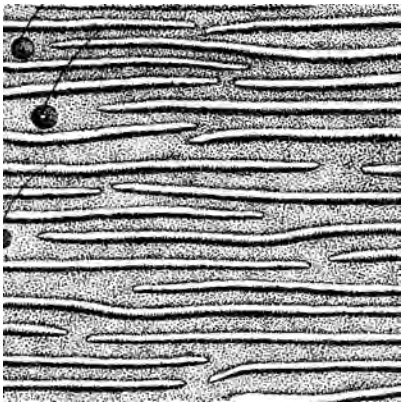
Conclusions. The microsculpture in cuckoo wasps is rather diverse. Its variety may be divided into a number of types, and further subdivided into a number of forms. The punctuation is the most common and most various type of surface microsculpture in Chrysididae. The characters of microsculpture, and punctuation especially, are of taxonomic value for this group of insects, therefore the accurate usage of terminology is needed. The differences in minute structure of punctures may further reveal the useful characters to distinguish taxa of cuckoo wasps. The general pattern of microsculpture of separate sclerites may be considered while ascertaining the relationships among the higher taxa of Chrysididae.

Table 1.

Main types and forms of microsculpture found in European cuckoo wasps

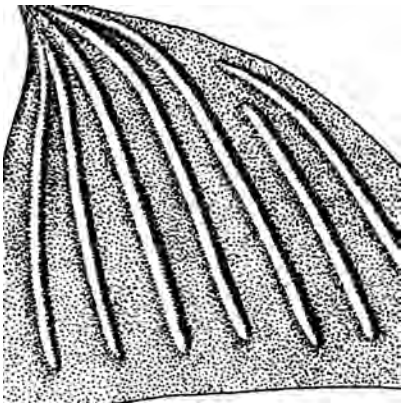
Striate microsculpture (ENG) Лінійчаста мікроскульптура (UA) Полосчатая микроскульптура (RUS)	
	**Aciculate** (ENG) Игольчато-исчерченная (RUS) Гольчасто-покреслена (UA) Surface with very fine, shallow, close and long striae; appearing as if irregularly scratched with a needle (Harris, 1979). Fig: *Pseudospinolia neglecta* ♀, scapal basin



Strigate (ENG)
Лінійчаста (UA)
Полосчатая (RUS)

Surface with numerous fine subparallel striae, either raised or impressed.

Fig.: *Stilbum calens* ♀, scapal basin.

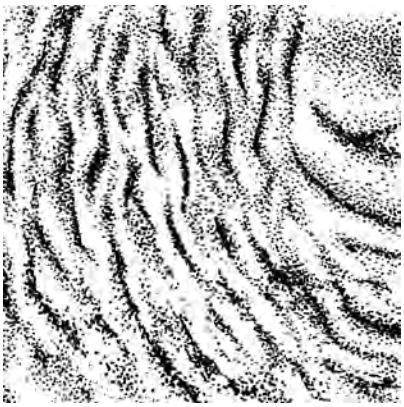


Canaliculate (ENG)
Ложбинчаста (UA)
Ложбинчатая (RUS)

Surface with wide longitudinal subparallel striae, either raised or impressed.

Fig.: *Cleptes striatipleuris* ♀, upper mesopleuron.

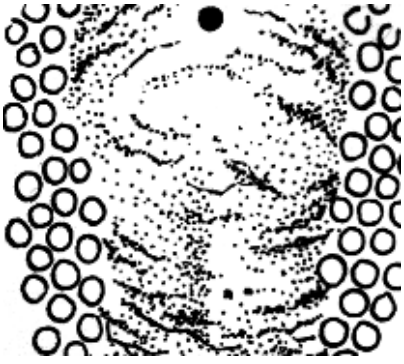
Rugose microsculpture (ENG)
Зморшкувата мікроскульптура (UA)
Морщинистая микроскульптура (RUS)



Rugulose (ENG)
Дрібнозморшкувата (UA)
Мелкоморщинистая (RUS)

Irregularly sculptured surface with numerous fine confluent rugae; minutely rugose (Harris, 1979).

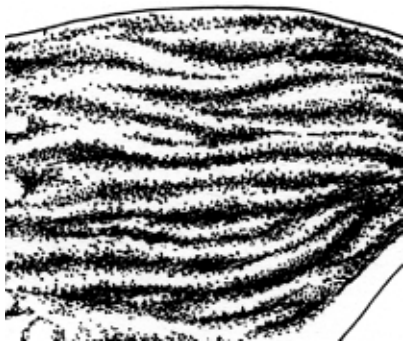
Fig.: *Chrysura pustulosa* ♂: lateral part of metanotum.



Rugose (ENG)
Зморшкувата (UA)
Морщинистая (RUS)

Surface with irregular large, either shallow or deep rugae.

Fig.: *Chrysis insperata* ♀, scapal basin.



Plicate (ENG)
Складчаста (UA)
Складчатая (RUS)

Surface impressed with deep irregular large folds.

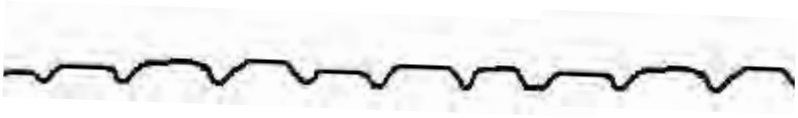
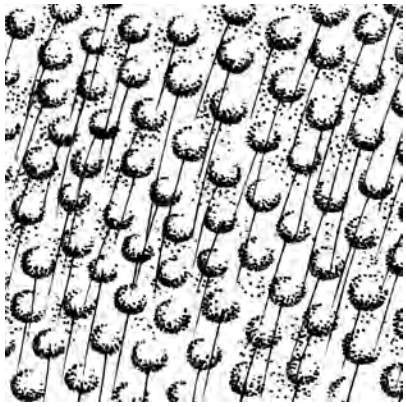


Fig.: *Hedychrum nobile* ♂, sides of pronotum.

Pustulate microsculpture (ENG)
Пустулезная микроскульптура (RUS)
Пустульозна мікроскульптура (UA)

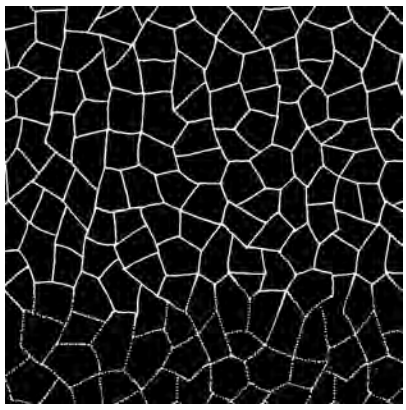


Pustulate, with setae (ENG)
Пустульозна, зі щетинками(UA)
Пустулезная, с щетинками (RUS)

Surface covered with small, blister-like and never with a terminal pore (Harris, 1979).

Fig.: *Chrysis zetterstedti* ♀, metasomal tergite II.

Coriaceous microsculpture (ENG)
Шкіряста мікроскульптура (UA)
Кожистая микроскульптура (RUS)



Alutaceous (ENG)
Дрібношкіряста (UA)
Тонкокожистая (RUS)

Surface covered with a net of very shallow, fine minute cracks.

Fig.: *Chrysis indigotea* ♂: proximal margin of metasomal sternum II.

Coriaceous (ENG)
Шкіряста (UA)
Кожистая (RUS)

Surface covered with minute cracks; leather-like in sculpture (Harris, 1979).

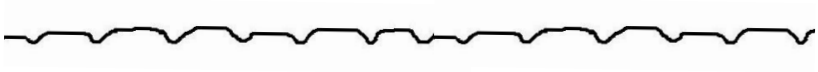
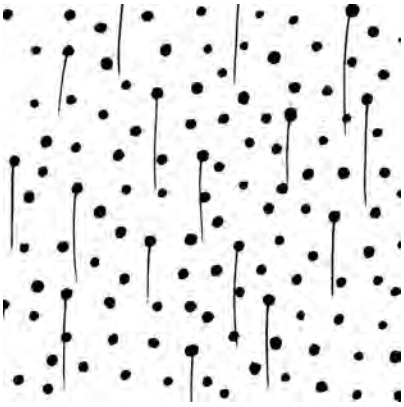


Fig.: *Chrysellampus sculpticollis* ♀, scutum.

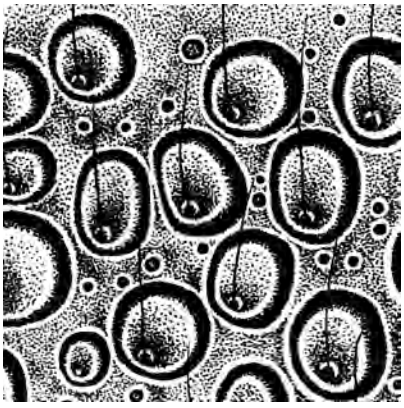
Punctuation, or punctate microsculpture (ENG)
Ямчаста мікроскульптура (UA)
Пунктировка, или точечная микроскульптура (RUS)



Punctulate (ENG)
Дрібноямчаста (UA)
Мелкоточечная (RUS)

Smooth surface with numerous uniform small, either deep or shallow punctures.

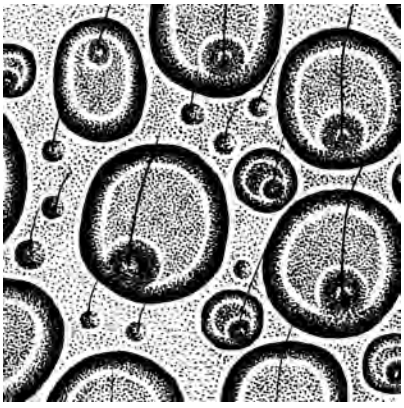
Fig.: *Philoctetes bidentulus*: metasomal tergite II.



Double-punctate (ENG)
Подвійно-ямчаста (UA)
Двояко-точечная (RUS)

Surface covered with two kinds of punctures that differ in structure or/and size.

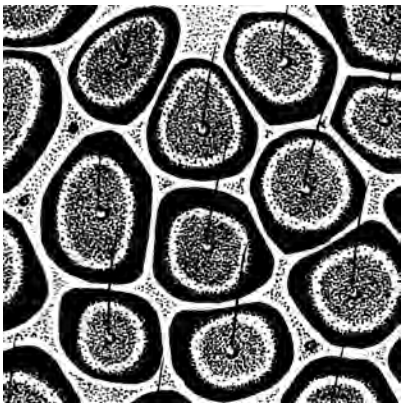
Fig.: *Chrysis inaequalis* ♀: scutellum.



Triple-punctate (ENG)
Потрійно-ямчаста (UA)
Трояко-точечная (RUS)

Surface with three types of punctures that differ in structure or/and size.

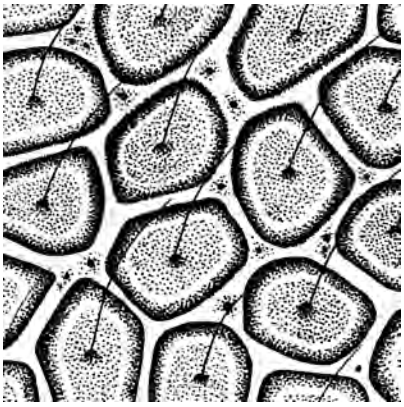
Fig.: *Chrysis zetterstedti* ♀: scutellum.



Rugose-punctate (ENG)
Складчасто-ямчаста (UA)
Складчато-точечная (RUS)

Surface covered with dense deep punctures; interstices between punctures form deep thin folds.

Fig.: *Hedychrum virens* ♀: metanotum.



Reticulate (ENG)
Сітчаста (UA)
Сетчатая (RUS)

Surface covered with dense flat-bottom punctures; interstices between punctures form a thin net.

Fig.: *Holopyga fastuosa generosa* ♂: pronotum.

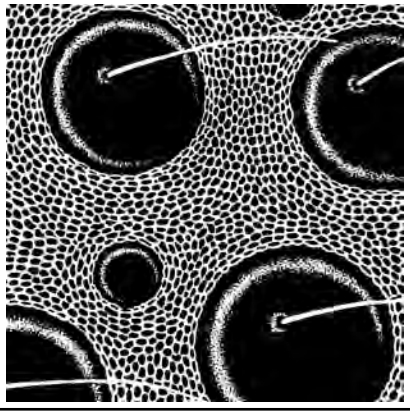
Table 2

Complex and combined forms of microsculpture found in cuckoo wasps.

D**ouble-punctulate** (ENG)
Подвійно-дрібноямчаста (UA)
Двояко-мелкоточечная (RUS)

Surface covered with small punctures of two kinds.

Fig.: *Pseudomalus violaceus*: metasomal tergite II.



Coriaceous and punctate (ENG)
Шкірясто-ямчаста (UA)
Кожисто-точечная (RUS)

Coriaceous surface bearing uniform punctures.

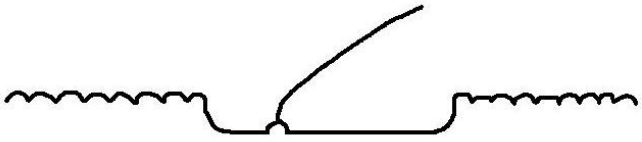
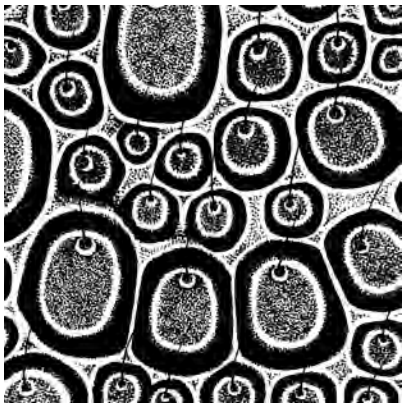


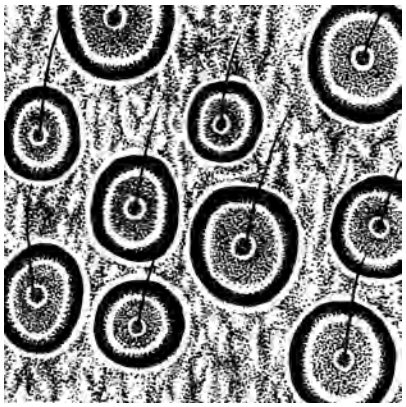
Fig.: *Chrysellampus sculpticollis* ♀: scutum.



Double rugose-punctate (ENG)
Подвійно-складчасто-ямчаста UA)
Двояко-складчато-точечная (RUS)

Surface covered with punctures of two kinds that differ in structure or/and size; and with interstices forming high folds.

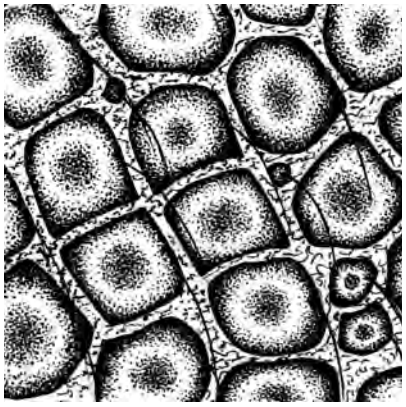
Fig.: *Pseudospinolia neglecta* ♀, scutellum



Rugulose-punctate (ENG)
Дрібнозморшкувато-ямчаста (UA)
Мелкоморщинисто-точечная (RUS)

Rugulose surface bearing uniform scattered punctures.

Fig: *Hedychrum nobile* ♀, scutellum.



Rugulose-reticulate (ENG)
Дрібнозморшкувато-сітчаста (UA)
Мелкоморщинисто-сетчатая (RUS)

Rugulose surface covered with dense shallow punctures.

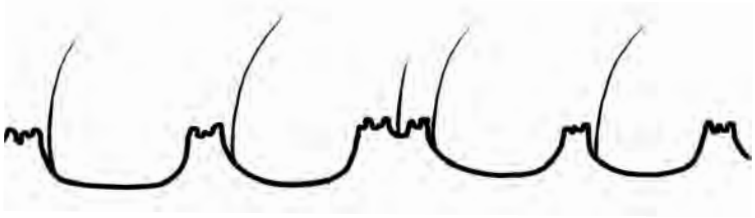
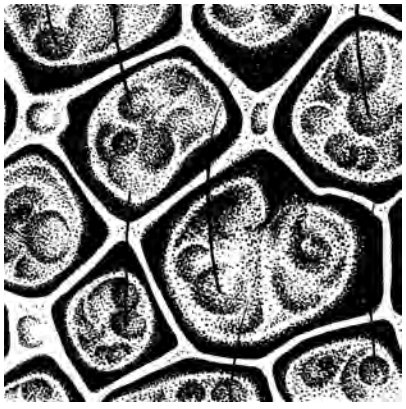


Fig.: *Chrysidea pumila*, metasomal tergite II.



Reticulate-rugose with foveolae punctures (ENG)
Сітчасто-складчаста з мілкими ямками (UA)
Сетчато-складчатая с мелкими ямками (RUS)

Surface densely covered with foveolate punctures and with interstices forming high folds.

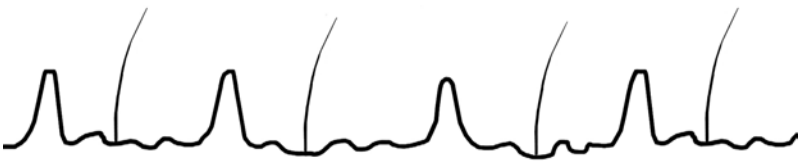
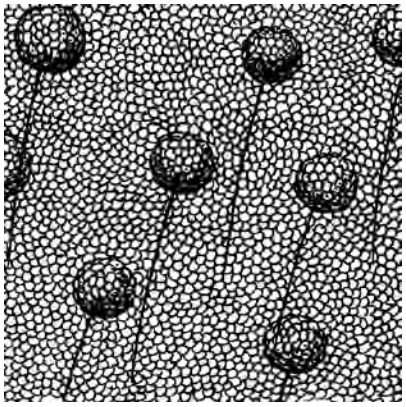


Fig:. *Hedychridium iucundum* ♂, metanotum.



Coriaceous-papillate (ENG)
Шкірясто-пустульозна (UA)
Кожисто-сосочковидная (RUS)

Coriaceous surface bearing papillae with setae.

Fig.: *Chrysis chrysoprasina* ♂: metasomal stergite II.

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